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Wireless Battery Management System for Safe High-Capacity Energy Storage

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Wireless Battery Management System for Safe High-Capacity Energy Storage

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The new technology discussed here will enable wireless monitoring and communication with a wide variety of mobile and stationary energy storage systems, including primary and secondary batteries, such as lithium-ion batteries, capacitors, fuel cells, engines, hybrids, converters, photovoltaic cells, thermoelectric generators, gas and steam turbines, sterling engines, electrical generators and motors, fuel tanks and sub-stations. Given the safety challenges facing lithium-ion batteries in EV applications, such sensors may be particularly important to the emerging EV market. These wireless suites of sensors and readers eliminate the need for massive wiring harnesses necessary to carry sensor signals, and allows for the painless incorporation of large arrays of sensors for the control of hybrid energy systems, as well as enhanced performance, safety, and reliability. This increases operating efficiency, prolongs life of system, and increases reliability. The proposed work leverages advancements made from an earlier ARPA-e funded project that developed prototype sensors for wireless battery management systems for lithium-ion battery packs. The accomplishments that will be reported include: (1) flexible wireless tags and sensors, using Bluetooth 4.0 standard; (2) small receivers compatible with USB ports on portable computers; (3) software drivers and logging software; (4) flexible wireless controllers, also using Bluetooth 4.0 standard, essential for balancing large-scale battery packs; (4) demonstrations performed to date, with examples of the data acquired.

Large lithium-ion battery packs for space exploration require extensive wiring harness, as shown in Figure 1. More sensors are needed for enhanced safety in such systems, without the proliferation of wires. Elimination of such wiring harnesses promise to increase reliability, decrease weight, and increase mass-specific power and energy. The proposed wireless sensors and controllers illustrated with Figure 2 provide a means of eliminating the massive wiring harnesses, and are capable of increasing safety, reliability, specific power, and specific energy. Prototypical passive wireless sensors, like the one shown in Figure 3, are capable of simultaneously monitoring several voltages, current, strain and temperature, ideally suited for monitoring energy conversion and storage devices, including but not limited to photovoltaic cells, thermoelectric generators, primary and secondary electrochemical batteries, capacitors, flywheels, and various types of generators.

Wireless voltage sensors, being operated in a passive mode, are capable of following terminal voltage of individual lithium-ion cells in battery pack during charge-discharge cycling, as shown in Figure 4. Similarly, wireless temperature sensors are capable of following the temperatures of individual lithium-ion cells in high-capacity battery pack during charge-discharge cycling, with representative data shown in Figure 5. The same capability can be used for monitoring localized temperatures from a large array of distributed thermistors. Wireless strain gauges are capable of following the swelling of individual lithium-ion cells in battery pack, as shown in Figure 6. The same capability can be used for monitoring localized strain in individual cells, from a large array of distributed strain gauges, as indicators of internal pressure in the cells.

Acknowledgements

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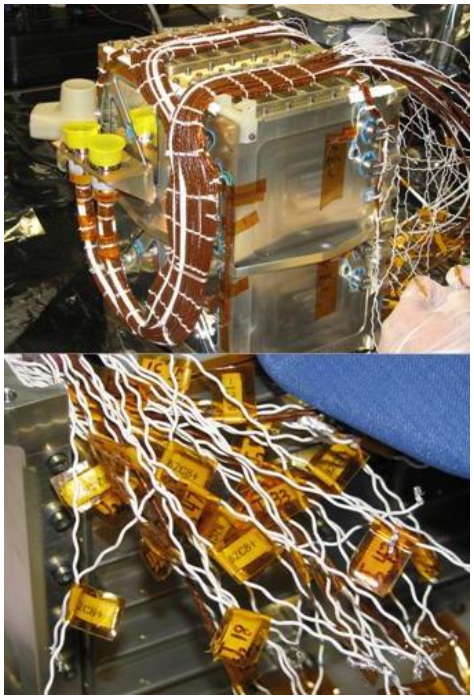

Figure 1 –2.5 kWh Li-Ion battery pack for NASA's Mars Science Laboratory requires extensive wiring harness; more sensors are needed in such systems without the proliferation of wiring harnesses. Elimination of the wiring harness promise to increase reliability, decrease weight, and increase mass-specific power and energy.

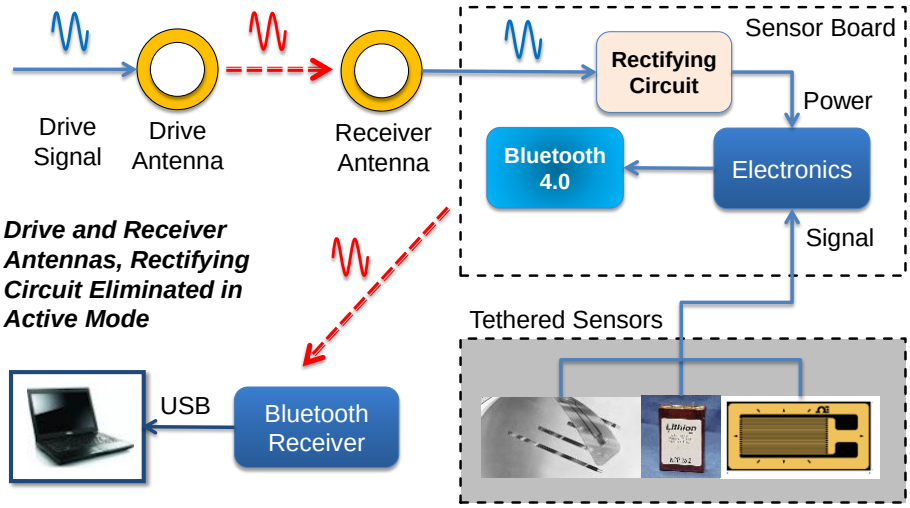

Figure 2 – The proposed wireless sensors and controllers provide a means of eliminating the massive wiring harnesses, and are capable of increasing safety, reliability, specific power, and specific energy.

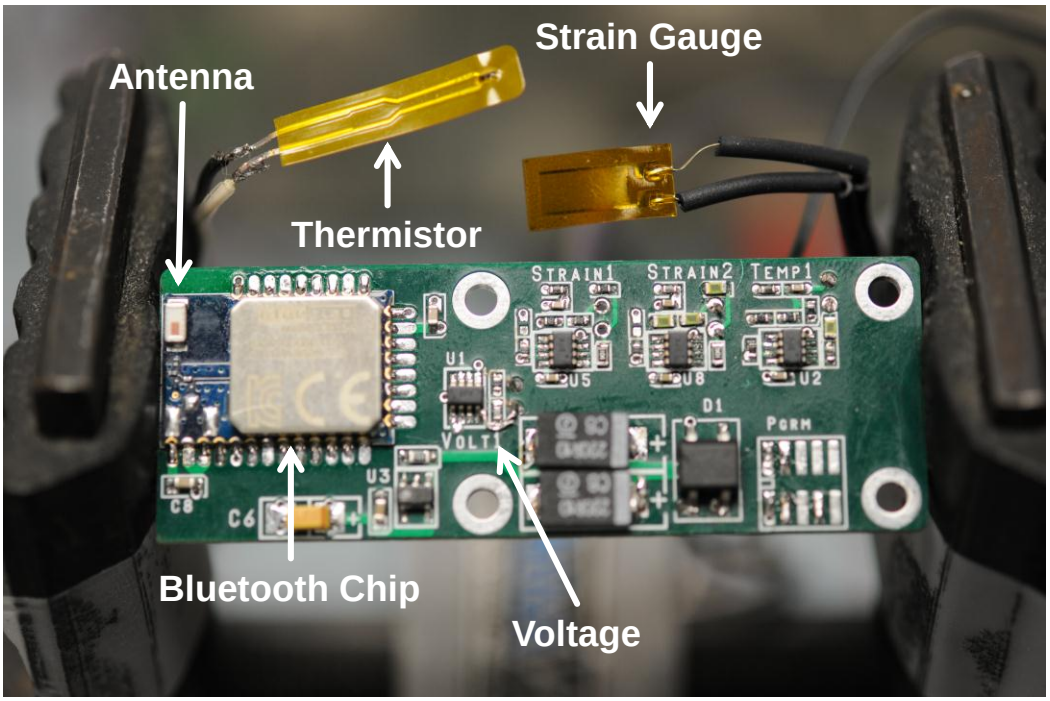

Figure 3 – Prototypical passive wireless sensor capable of simultaneously monitoring several voltages, current, strain and temperature, ideally suited for monitoring energy conversion and storage devices, including but not limited to photovoltaics, thermoelectric generators, primary and secondary electrochemical batteries, capacitors, flywheels, and various types of generators.

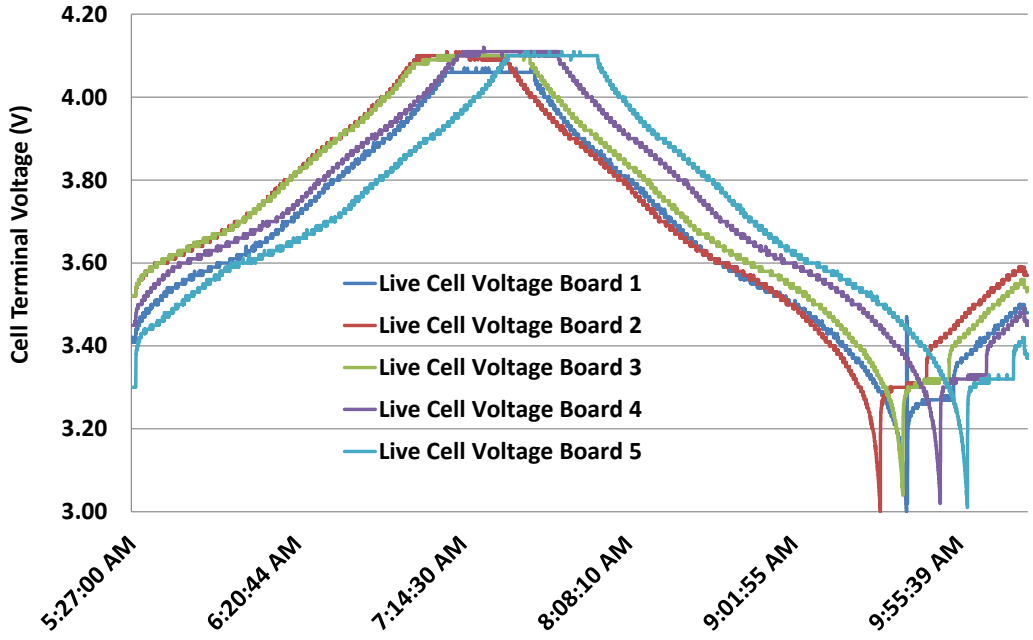

Figure 4 – Passive RFID voltage sensors following terminal voltage of individual lithium-ion cells in battery pack during charge-discharge cycling.

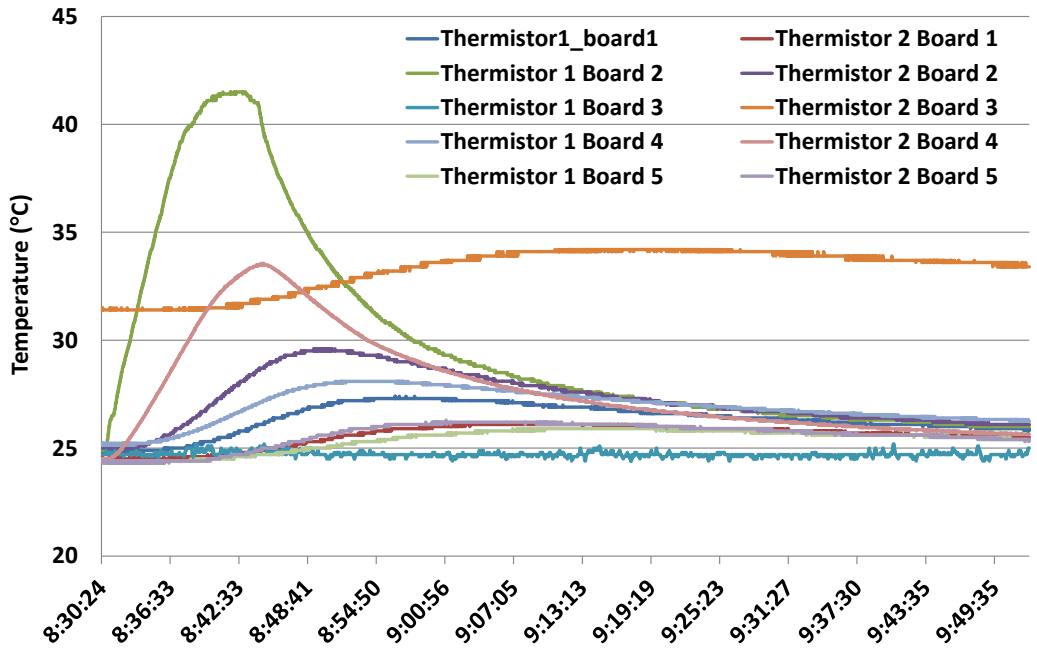

Figure 5 – Passive RFID temperature sensors following the temperatures of individual lithium-ion cells in battery pack during charge-discharge cycling. The same capability can be used for monitoring localized temperatures from a large number distributed thermistors.

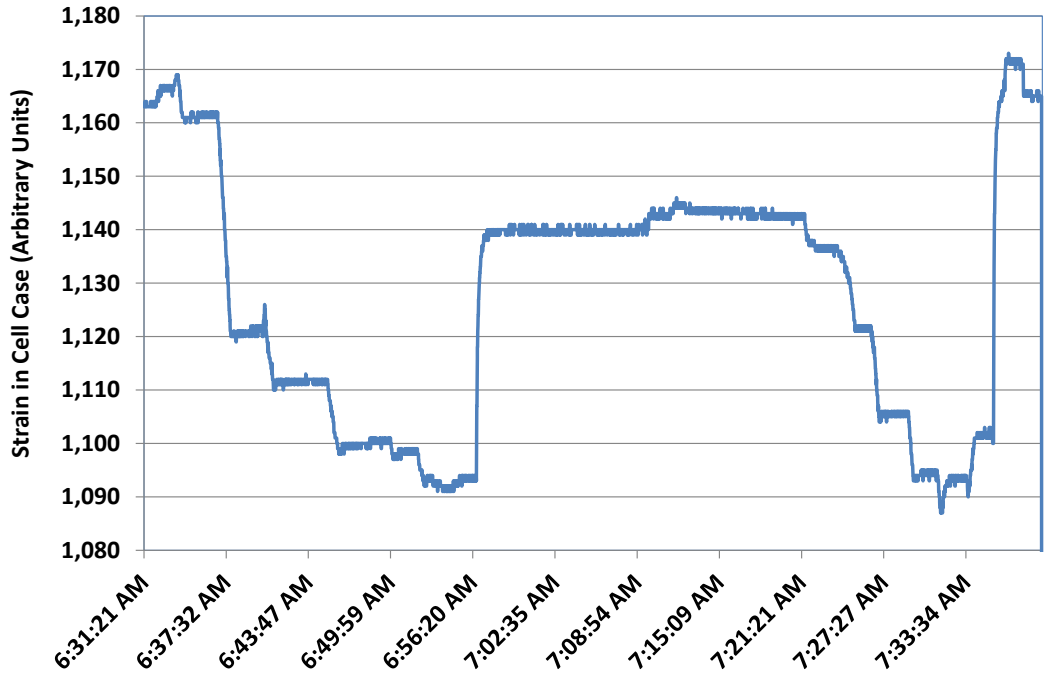

Figure 6 – Passive RFID strain gauges following the swelling of individual lithium-ion cells in battery pack. The same capability can be used for monitoring localized strain, as an indicator of cracking, from a large number distributed strain gauges.